UNIVERSITI PUTRA MALAYSIA

SPATIAL VARIABILITY OF OIL PALM LEAF NUTRIENTS AND YIELD

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By

RIDUAN BIN MOHD JUNUSI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

July 2006

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'DEDICATED TO MY BELOVED PARENTS, MY DEAR WIFE WHO PUTS UP WITH ME AND MY PURSUIT OF THIS THESIS, AND ALSO TO OUR DAUGHTER'

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Duan, 2006
upmkb

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: **Associate Professor Sr. Abdul Rashid Mohammed Shariff, PhD**

Faculty: **Engineering**

In recent times, among the major problems in oil palm plantation is the lack of proper interpretation of yield maps for site-specific management, the identification, and understanding of the causal factors influencing the variability of oil palm yields. The ability to find and comprehend the leaf factors influencing yield variability of oil palm will help in managing the plantation efficiently for better yield. The study of Spatial Varibility of Oil Palm Leaf Nutrients and Yield was carried out at Dusun Durian Estate, Golden Hope Plantations Berhad, Banting, Selangor, in a 15 ha plot which was a coastal oil palm plantation. The objective of this study was to obtain accurate and timely information about the spatial distribution and status of nutrients in the leaf tissue using Geographic Information System (GIS) for precision farming of oil palm plantation. Collection of leaf tissue data were conducted using systematic sampling and an AgGPS Trimble was used to precisely

determine the sampling locations. Geostatistics (GS+) software and classical statistics were used for data analysis. Leaf nutrient analysis illustrated that the leaf nutrient variability of N, P, K, Ca and Mg from year 2000 to 2003 could be classified as low whereas coefficient of variation (CV) values of 2.0 to 2.2, 1.9 to 3.0 and 1.9 to 5.3, 5.7 to 7.4 and 6.6 to 7.4 respectively. Based on the semivariance analysis, leaves nutrients have a moderately spatial dependence with the lag distances of 311 to 314 m, 161 to 249 m, 185 to 311 m and 169 to 314 m for N, P, K and Ca, respectively. Meanwhile, Mg have a strong spatial dependence (S) with the lag distance is 94 to 183 m. The variability of fresh fruit bunch (ffb) is moderate and is moderately spatial dependence with the lag distance of 310 to 314 m. There is a strong relationship between FFB yield, N and P in leaf tissue. This result implies that N and P in leaf tissue can be used to determine the FFB yields.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

VARIASI RUANG KANDUNGAN NUTRIEN DAUN SERTA HASIL PADA KELAPA SAWIT

Oleh

RIDUAN MOHD JUNUSI

Julai 2006

Pengerusi: Profesor Madya Sr. Abdul Rashid Mohammed Shariff, PhD

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Pada masa kini cabaran utama dalam penanaman kelapa sawit adalah interpretasi peta hasil yang sesuai untuk pengurusan tapak spesifik, dan identifikasi serta pemahaman faktor-faktor yang mempengaruhi variasi hasil kelapa sawit. Kemampuan untuk menemui dan memahami faktor-faktor nutrien daun yang mempengaruhi variasi hasil tuaian kelapa sawit akan membolehkan pengurusan secara lebih efisien. Satu kajian telah dijalankan di kawasan pesisiran pantai ladang Dusun Durian Estate, Golden Hope Plantations Berhad, Banting, Selangor, dengan keluasan 15 ha. Secara amnya tujuan penyelidikan ialah untuk memperoleh data yang pasti dan tepat masa hal pergantungan ruang dan kadar nutrient di dalam daun menggunakan Sistem Maklumat Geografi (GIS) untuk pertanian tepat bagi ladang kelapa sawit. Pengumpulan sampel daun dikerjakan bersistem dengan bantuan AgGPS Trimble untuk penetapan kedudukan pasti daripada sampel. Perisian Geostatistics (GS+) dan statistik biasa telah pun digunakan untuk penganalisaan data. Analisis nutrien di dalam daun menunjukkan bahawa nutrien di dalam daun daripada N, P, K, Ca dan Mg dari tahun 2000

– 2003 diklasifikasikan sebagai rendah (nilai sisihan piawai (CV), masing-masing dari 2.0 hingga 2.2, 1.9 hingga 3.0 dan 1.9 hingga 5.3, 5.7 hingga 7.4 dan 6.6 hingga 7.4). Berdasarkan kepada semivarian analisis, nutrien di dalam daun mempunyai pergantungan ruang sederhana dengan jarak 311 hingga 314 m, 161 hingga 249 m, 185 hingga 311 m dan 169 hingga 314 m, berturut-turut untuk N, P, K dan Ca. manakala, Mg pula mempunyai pergantungan ruang yang kuat dengan jarak 94 hingga 183 m. Hasil buah tandan segar (ffb) mempunyai variasi yang sederhana dan kebergantungan ruang yang sederhana dengan jarak 310 hingga 314 m. Terdapat hubungan yang kuat di antara ffb dengan N dan ffb dengan P pada daun. Keputusan ini menunjukkan bahawa N dan P di dalam daun boleh digunakan untuk menentukan hasil buah tandan segar.

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I certify that an Examination Committee has met on 18 July 2006 to conduct the final examination of Riduan Mohd Junusi on his Master of Science thesis entitled "Spatial Variability of Oil Palm Leaf Nutrients and Yield" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of University Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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RIDUAN B MOHD JUNUSI

Date: 19/9/2006

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LIST OF ABBREVIATIONS

AgGPS	Agriculture Global Positioning System
ANOVA	Analysis of variance
ATP	Adenosine triphosphate
B	Boron
C	Calcium
°C	Degree Celcius
CEC	Cation exchange capacity
CIRP	Christmas Island rock phosphate
cm	Centimeter
cmol	Centimol
CTC	Crop Termination Chemicals
CV	Coefficient of Variation
DOA	Department of Agriculture
DNA	Deoxiribonucliec acid
EFB	Empty fruit bunch
FFB	Fresh fruit bunch
GIS	Geographic Information System
GIT	Geospatial Information Technology
GPS	Global Positioning System
GS+	Geostatistics Software
ha	Hectare

K	Potassium
km	Kilometer
m	Meter
milimohs	mililiter per milion per hectare
mm	Millimeter
ms^{-1}	Meter per second
mm yr^{-1}	Milimeter per year
Mg	Magnesium
MOP	Muriate of potash
N	Nitrogen
P	Phosphorus
PF	Precision Farming
PGRs	Plant Growth Regulators
RNA	Ribonucleic acid
RSS	Residual sums of squares

CHAPTER 1

INTRODUCTION

1.1 Background

The oil palm, *Elaeis guineensis*, Jacq., which is native to the swamps of West Africa, was introduced to Malaysia in 1875 (Arnott, 1963) as an ornamental plant. The expansion of the oil palm industry started in the late 1960s under the crop diversification plan, when 55,000 hectares were planted. It was then increased by more than sixty fold to a total of 3.3 million ha in 1999. Approximately 50% of the total arable land in Malaysia is cultivated with oil palm. Malaysia is currently the world's largest producer and exporter of palm oil, producing 10.5 million tones of crude palm oil, contributing RM 19.2 billion of the gross revenue (MPOB, 2000).

However, since 1975, substantial increase in oil palm areas has not matched its productivity in terms of fresh fruit bunch (ffb) yields. The average ffb yields had remained in a range of 18 to 22 t ha-1 yr-1 for the past 20 years (MPOB, 2000). This yield is well below the theoretical yield potential of 44 t ha-1 yr-1 (Tinker, 2000). Many of the interacting factors influencing the yield trend were identified and quantified by various researchers in the industry such as Foster *et al.* (1985), Kee *et al.* (1994) and Goh and Teo (1994). Goh *et al.* (2000)

contended that "increased field size or management unit, generalized agricultural inputs and monitoring, declining management standards, lack of skilled workers and poor understanding of agronomy, exacerbated by the planting of oil palm on soil and climatic conditions previously deemed as marginal or unsuitable and the replanting of the rubber and cocoa on hilly, poor soils to oil palm are among the causal factors of the dismal yield performance".

Traditionally, the management of soil in oil palm plantations is based on large-scale extensive agricultural practices. The general practice is to demarcate the plantations into similar management zones that are based on very generalized soil information, palm age, terrain, and available infrastructure for similar input. Currently, the typical management zone ranges between 40 to 100 ha (Chew and Anuar, 2000; Goh et al., 2000). However, it is probably too large and the present fertilizer recommendations that are based on very general soil information may not be an effective way to reduce production cost and maximize profit; the most important factors towards sustainable oil palm production. Adequate N, P, K, Ca and Mg fertilizer management is of great importance as these macronutrients are the bulk of the fertilizer bill. Excessive N, P, K, Ca and Mg fertilizer could result in a higher risk of nutrient losses through surface run-off (Maene et al., 1979; Kee et al., 2000), and leaching (Chang and Zakaria, 1987; Foong, 1993), which may contaminate ground water. Similarly, under estimation of fertilizer rates may restrict oil palm growth and lead to sub-optimal production.

Precision farming, defined as a spatial variable management in order to increase efficiency in the management of agricultural practices, productivity and profitability, and reduce the environmental impact, seems to offer some solutions to the aforementioned problems. However, the success and applicability of precision farming technique for oil palm plantations lies in the existence of manageable ffb yield variations (Goh et al., 1994), which is the single most important factor influencing profit (Goh and Chew, 2000a; Ong, 2000), and soil variations, which affect fertilizer input, the largest cost item in oil palm production (Kee and Chew,1996). In other words, the real opportunity to optimize fertilizer inputs through site-specific management zoning lies in the understanding of the large variation that exists in plantation. Proper management zoning needs to be taken into the account of ffb's spatial yield variations. Besides, the existing of soil variability for optimum oil palm growth and production should also be considered with the invention of new technologies. This includes proper interpretation of multiple-year yield maps, and identification and understanding the causal factors affecting the yield variations of oil palm.

1.2 Problem Statement

In general, oil palm plantations are managed based on conventional technology of large-scale extensive agricultural practices. It appears inevitable to intensify and improve the planting practices by developing new techniques to increase efficiency and productivity to keep ahead of competitors and maintain its reputation as a responsible “green industry”.

Nutrient balance is needed in order to make safe the level of production required as well as ensuring that soil fertility is maintained and preferably improved. Foliar analysis is carried out to quantify the deficiency of individual nutrients so that fertilizer adjustments can be calculated. Optimum leaf nutrient levels correspond to maximum yield (Foster *et al.,* 1987).

In PF, information on soil and plant nutrient status of oil palm is very important and useful for fertilizer recommendation. The major problem remains with knowledge of the critical factors and their effects on growth and yield besides knowledge of important nutrient budget requirements in the oil palm systems.

Generally fertilizers are applied homogenously and in an indiscriminate way without any regard to the actual soil deficiency in nutrients. In one hand it leads to wastage of fertilizers and on the other, areas of land are not provided the optimum amount of nutrients required to maximize yield.

1.3 Goals and Objectives

The goal of this study was to obtain the relationship between leaf nutrient variability and yield of oil palm, using GIS for precision farming. The specific objectives were as follows:

1. To establish a relationship between nutrient status in the leaf tissue and FFB yield of oil palm.
2. To determine the status of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) levels in the leaf tissue.
3. To assess the spatial pattern of N, P, K, Ca and Mg status in the leaf tissue, and yield of FFB using GPS and geostatistical analysis

The study area is at Dusun Durian Estate, Banting, Selangor.

CHAPTER 2

LITERATURE REVIEW

2.1 Precision Farming

PF is an emerging technology that modifies existing techniques and incorporates new ones to produce a new set of tool for land manager to use. Therefore, PF is not simply the ability to apply treatments that are vary locally, but it also considers the ability to precisely monitor and assess an agricultural enterprise. Therefore an understanding of the processes involved in achieving successful application of inputs for attaining a set goal is essential. In addition, there is a need to have sufficient understanding of the processes involved to be able to apply the inputs in such a way as to be able to achieve a particular goal. This is not necessarily to achieve maximum yield but to maximize financial gain while operating within environmental constraints.

Many developments in PF concern with the monitoring of in-field crop output (yield) variation. In this manner, this technology may reduce input costs and thereby increase profitability. However, it should be remembered that other agricultural operations can also represent significant input costs, and the level standards at which they performed can affect both crop development and input